Urban Water Management in Singapore

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Singapore's water management policies have been of interest to many countries around the world. This article is based on a paper prepared for the 2006 Human Development Report.

Singapore is a city state with an area of about 700 km^2, a population of approximately 4.4 million people, and annual growth of 1.9 percent. The average GDP growth of 7.7 percent per year during the last decade has resulted in economic prosperity, which has been translated into steady improvements in the socio-economic conditions of the country.

One of the main concerns of the government has been how to provide clean water to the population, which currently consumes about 1.36 billion litres of water per day. Singapore is considered to be a water-scarce country not because of lack of rainfall (2,400 mm/year), but because of limited amount of land area to store the rainfall. Singapore imports water from the neighbouring Johor state of Malaysia, under long-term agreements signed in 1961 and 1962, when Singapore was still a self-governing British colony. Under these agreements, Singapore can transfer water from Johor for a price of less than 1 cent per 1,000 gallons until the years 2011 and 2061 respectively. The water from Johor is imported through three large pipelines across the 2-km causeway that separates the two countries.

In August 1965, Singapore became an independent country. Long-term water security was an important consideration for this newly independent nation. Malaysia and Singapore have been negotiating the possible extension of the water agreement. Singapore would like to ensure its long-term water security by having a treaty which will provide it with water well beyond the year 2061. The main Malaysian demand has been for a higher price of water, which has varied from 15 to 20 times the present price. Singapore's main concern has been how the price revision will be decided

Because of this continuing stalemate, Singapore has developed a new plan for increasing water security and self-sufficiency during the post 2011-period, with increasingly more efficient water management, including formulation and implementation of new water-related policies, heavy investments in desalination and extensive reuse of wastewater, and catchment management and other similar actions.

Institutionally, Public Utilities Board (PUB) currently manages the entire water cycle of Singapore. Earlier, PUB was responsible for managing potable water, electricity and gas. On April 1, 2001, the responsibilities for sewerage and drainage were transferred to PUB from the Ministry of the Environment. This transfer allowed PUB to develop and implement a holistic policy. The country is now fully sewered to collect all wastewater, and the separate drainage and sewerage systems have facilitated wastewater reuse on an extensive scale.

OVERALL APPROACH

Singapore's success in managing its water and wastewater is its concurrent emphasis on supply and demand management, wastewater and stormwater management, institutional effectiveness and creating an enabling environment, which includes a strong political will, effective legal and regulatory frameworks and an experienced and motivated workforce. The Singapore example indicates that it is unrealistic to expect an efficient water management institution in a country, in the midst of mediocre management institutions, be they for energy, agriculture or industry. Water management in a country can only be as efficient as the management of other development sectors. The current implicit global assumption that water management institutions can be improved unilaterally when other development sectors remain somewhat inefficient is simply not a viable proposition.

SUPPLY MANAGEMENT

Singapore is one of the very few countries that looks at its supply sources in its totality. In addition to import of water from Malaysia, it has made a determined attempt to protect its water sources, expand its available sources by desalination and reuse of wastewater, and use technological developments to increase water availability, improve water quality management and steadily lower production and management costs. PUB, at present, has an in-house Centre for Advanced Water Technology, with about 50 expert staff members who provide it with necessary R&D support.

Over the years, catchment management has received increasing emphasis. Protected catchment areas are well demarcated and gazetted, and no pollution-causing activities are allowed in such protected areas. In land-scarce Singapore, protected catchment classification covers less than 5% of the area.

The Trade Effluent Regulations of 1976, promulgated the idea of partly-protected catchments, where wastewater discharges to streams require prior treatment. The effluents must have an acceptable water quality that has been defined. While many other developing countries have similar requirements, the main difference is that, in Singapore, these regulations are strictly implemented. For example, when wastes from pig farms became a major source of water contamination, the Cattle Act was legislated to restrict the rearing of cattle to certain areas in the interest of public health. This also protects the water catchments from animal wastes generated from the cattle farms. At present, half of the land area of Singapore is considered to be protected and partly-protected catchment. This ratio is expected to increase to two-thirds by 2009.

Desalination is becoming an important component for augmenting and diversifying available national water sources. In late 2005, the Tuas Desalination Plant, the first municipal-scale seawater desalination plant, was opened at a cost of S$200 million. Designed and constructed by a local water company, it is the first design, build, own and operated desalination plant in the nation. The process used is reverse osmosis and it has a capacity of 30 mgd (million gallons per day). The cost of the desalinated water during its first year of operation is S$0.78/m^3.

Faced with the strategic issue of water security, Singapore considered the possibility of recycling wastewater (or used water) as early as 1970s. It opted for proper treatment of used water. However, the first experimental recycling plant was closed in 1975 because it proved to be uneconomical and unreliable: the technology was simply not available three decades ago to

make such a practical plant.

In 1998, a Water Reclamation Study by the then-Ministry of the Environment and PUB was set up to determine the suitability of using reclaimed water to supplement our water supply. An international panel of experts was assembled in 1998 to provide independent advice and assessment. In 2000, a 2 mgd demonstration plant at Bedok Water Reclamation Plant commenced operation. The demonstration plant confirmed the safety and potability of NEWater. The Expert Panel, in 2002, endorsed that NEWater is safe and sustainable source of water supply for Singapore.

The quality of NEWater was found not only to exceed water quality standards of the Environmental Protection Agency of the United States and the World Health Organisation, but was also better than the water supplied by PUB.

The supply is also being increased through collection, treatment and reuse of wastewater. Investments in 2003 for the expansion and upgrading of water reclamation facilities were $116 million . During the 2002-2004 period, the amount of wastewater that was treated has increased from 1.315 to 1.369 MCM/day.

After this successful demonstration, PUB decided to produce NEWater on a large scale to supplement its traditional supplies, a step that very few countries have taken. Wastewater is reclaimed after secondary treatment by means of advanced dual-membrane and ultraviolet technologies. NEWater is used for industrial and commercial purposes, even though it is safe to drink. Since its purity is higher than tap water, it is ideal for certain types of industrial manufacturing processes, like semiconductors which require ultrapure water. It is thus economical for such plants to use NEWater since no additional treatment is necessary to improve water quality. With more industries using NEWater, more PUB water could be freed up for potable use.

Singapore is able to produce NEWater as Singapore has separate drainage and sewerage systems. As Singapore is 100% sewered, all wastewater is collected and treated to international standards fit for discharge to the sea or for reuse.

A small amount of NEWater (about one percent of the daily consumption of the country) is blended with raw water in the reservoirs, which is then treated for potable use. It is expected that, by 2011, Singapore will produce 65 mgd of NEWater annually, 10 mgd (2.5 percent of water consumption) for indirect potable use, and 55 mgd for industrial and commercial use.

There are at present three plants producing NEWater plants at Seletar, Bedok and Kranji. These plants have a total capacity of 20 mgd and will provide water to the north-eastern, eastern and northern parts of Singapore, respectively, served by a distribution network of more than 100km of pipelines. PUB has recently awarded another PPP project to construct the country´s largest NEWater factory at Ulu Pandan, with a capacity of 25 mgd. This plant will supply water to the western part and central business district of Singapore. Once this plant is operational, the overall production of NEWater will represent more than 10% of the total water demand per day. The overall acceptance of this recycled ultra-pure water has been high. By 2011, NEWater is expected to meet 15 percent of Singapore´s water needs.

The first year tender price for NEWater from the Ulu Pandan plant is S$0.30/$m^3$, which is significantly less than the cost of desalinated water. The selling price of NEWater is S$1.15/ m^3, which covers production, transmission and distribution costs. Because the production cost of NEWater is less than that of desalinated water, future water demands are planned to be covered with more NEWater rather than with construction of desalination plants.

The supply of water is further expanded by reducing unaccounted for water (UFW), which is defined as actual water loss due to leaks, and apparent water loss arising from meter inaccuracies. Unlike other South and South-east Asian countries, Singapore simply does not have any illegal connections to its water supply systems.

As shown in Figure 1, in 1990, unaccounted for water (UFW) was 9.5% of the total water production. Even at this level, it would still be considered to be one of the best examples in the world at the present time. However, PUB has managed to lower the UFW consistently to around 5% in recent years. This is a level which no other country can match at present. In comparison, in England and Wales, the only region in the world which has privatised its water more than a decade ago, the best any of its private sector companies have managed to achieve is more than twice the level of Singapore. Similarly, UFW in most Asian urban centres now range between 40 and 60%.

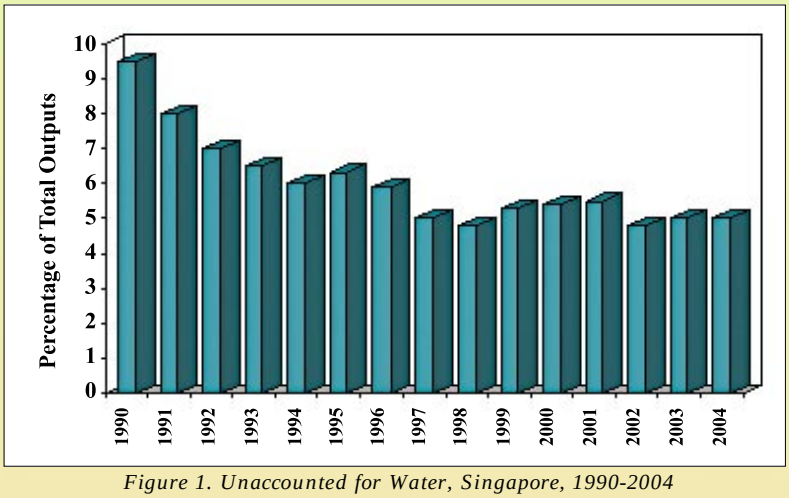

Figure 1. Unaccounted for Water, Singapore, 1990-2004

DEMAND MANAGEMENT

Concurrent with the diversification and expansion of water sources, PUB has put in place a well thought out and comprehensive demand management policy. It is useful to review the progress of water tariffs for water during the 1997-2000 period.

Before July 1, 1997, the first 20 m^3 of domestic consumption for each household was charged at S$0.56/$m^3$. The next block of 20 to 40 m^3 was charged at S$0.80/$m^3$. For consumption of more than 40 m^3/month and non-domestic consumption, it was S$1.17/$m^3$.

Effective July 1, 2000, domestic consumption of up to 40 m^3/month and non-domestic uses were charged at a uniform rate of S$1.17/$m^3$. For domestic consumption of more than 40m^3/month, the tariff became S$1.40/$m^3$, which is higher than non-domestic consumption. The earlier cheaper block rate for the first 20 m^3 of domestic consumption was eliminated.

In addition, the water conservation tax (WCT) that is levied by the Government to reinforce the water conservation message, was 0% for the first 20m^3/month consumption prior to July 1, 1997. For consumption over 20 m^3/month, WCT was set at 15%. Non-domestic users paid a WCT levy of 20%.

ITEM	1995	2000	2004
Average monthly consumption, m^3	21.7	20.5	19.3
Average monthly bill, inclusive of all taxes	S$14.50	S$31.00	S$29.40

Table 1. Average monthly consumption and bills per household, 1995, 2000, 2004

Effective July 1, 2000, WCT was increased to 30% of the tariff for the first 40 m^3/month for domestic consumers and all consumption for non-domestic consumers. However, domestic consumers paid 45% WCT, when their water consumption exceeds 40 m^3/month. In other words, there is now a financial disincentive for higher water consumption by the households.

Similarly, water-borne fee (WBF), a statutory charge prescribed to offset the cost of treating used water and for maintenance and extension of public sewerage system, was S$0.10/$m^3$ for all domestic consumption prior to July 1, 1997. Effective July 1, 2000, WBF was increased to S$0.30/$m^3$ for all domestic consumption. Impacts of these tariff increases on the consumers can be seen in Table 1.

Average monthly household consumption has steadily declined during the 1995-2004 period (Table 1). The consumption in 2004 was 11% less than in 1995. During the same period, the average monthly bill has more than doubled.

Figure 2 shows the domestic water consumption per capita per day over the 1995-2005 period. It shows steady decline in per capita consumption because of implementation of demand management practices, from 172 lpcd in 1995 to 160 lpcd in 2005.

These statistics indicate that the new tariffs had a notable impact on the behaviour of the consumers, and have turned out to be an effective instrument for demand management. This is a positive development since the annual water demands in Singapore increased steadily, from 403 million m^3 in 1995 to 454 million m^3 in 2000. The demand management policies introduced have resulted in lowering of this demand, which declined to 440 million m^3 in 2004.

In terms of equity, the Government provides specially targeted help for the lower income families. Households living in 1- and 2-room flats receive higher rebates during difficult economic times. For hardship cases, affected households are eligible to receive social financial assistance from the Ministry of Community Development, Youth and Sports.

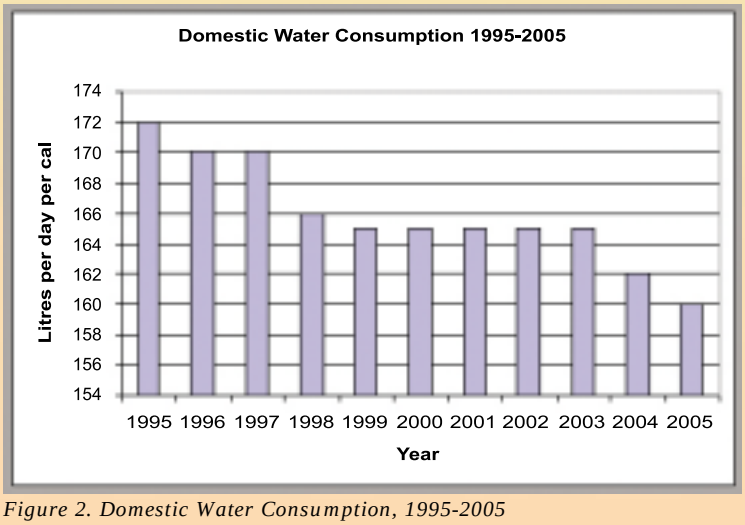

Figure 2. Domestic Water Consumption, 1995-2005

The current tariff structured used by PUB have several distinct advantages, among which are the following:

- There is no "lifeline" tariff which is used in many countries with the rationale that water for the poor should be subsidised since they cannot afford to pay high tariffs for an essential requirement for human survival. The main disadvantage of such a lifeline tariff is that it also subsidises water consumers who can afford to pay for the quantity of water they actually consume.
- The poor who cannot afford to pay for the current water tariffs receive a targeted subsidy. This is a much more efficient policy in socio-economic terms, instead of providing subsidised water to all for the first 20-30 m^3 of water consumed by all households, irrespective of their economic conditions.
- The current domestic tariff of water consumption up to 40 m^3/month/household is identical to the non-domestic tariff. Both are set at S$1.17/$m^3$. In other words, commercial and industrial users do not subsidise domestic users, which is often the case for numerous countries.
- The tariff structure penalises all those households who use more than 40 m^3 of water per month. They pay the highest rates, S$1.40 m^3, for consumption above this level. This rate is higher than the commercial and the industrial rates, and is a somewhat unusual feature compared to the existing norm.
- Water conservation tax (WCT) is 30% of the tariff for all consumers, except for domestic households who use more than 40 m^3/month. The WCT on consumption of each unit higher than 40 m^3/month goes up by 50%, from 30% to 45%, which must be having perceptible impacts on household behaviour in terms of water conservation and overall demand management.
- Water-borne fee (WBF) is used to offset the cost for treating wastewater and for the maintenance and extension of the public sewerage system. It is set at S$0.30 m^3/s for all domestic consumption. For non-domestic consumption, this fee is doubled, S$0.60/$m^3$, presumably because it is more difficult and expensive to treat non-domestic wastewater.
- A Sanitary Appliance Fee (SAF) is also levied per sanitary fitting per month. It is currently set at S$3.00 per fitting.
- There are two components to water tariff. A major component of the overall revenue collected through water tariffs accrue to the PUB recovering all operation and for considering maintenance costs and new investments. However, revenue from WCT accrues to the government and not to PUB.

OVERALL GOVERNANCE

The overall governance of water supply and wastewater management systems in Singapore is exemplary in terms of its performance, transparency and accountability. There is much that both the developed and developing world can learn from the PUB experience. Only some selected critical issues will be discussed herein.

HUMAN RESOURCES

An institution can only be as efficient as its management and the staff that work for it, and the overall social, political and legal environment within which it operates. In terms of human resources, PUB has some unique features in terms of management which makes it stand out among its other Asian counterparts.

In many Asian water utilities, service providers mostly have limited say on staff recruitment and staff remuneration. Consequently, the utilities face the following problems:

- Staff, including senior managers, is often selected because of their political connections, rather than their management abilities or technical skills. Managers often do not have the skill to manage, even if they had autonomy and authority to manage.
- Water utilities are overstaffed, primarily because of political interference and nepotism. Unions are very strong, and generally are well-connected politically. Accordingly, downsizing is a difficult task because of strong union opposition and explicit or implicit political support. Overstaffing ensures low productivity and low staff morale.
- Utilities are not allowed to pay their professional staff members the going market rates for remuneration. This means that they are unable to attract and retain right calibre of staff. Many staff moonlight to obtain extra income, and corruption is rife in nearly all levels.
- Utilities are dominated by engineers, and the career structure available for other disciplines like accountants, administrators, social scientists, information technologist, etc., is somewhat limited. This is another disincentive for non-engineers to join.
- Poor management, overstaffing, and promotions because of seniority or political connections ensure that it is very difficult to recruit good staff, and if some do join, it is equally difficult to retain them because of lack of job satisfaction, poor working environment and absence of incentives for good performance.

PUB has overcome the above and other related constraints through a competitive remuneration and incentives and benefits package. The salary and benefit package is generally benchmarked against the Civil Service, which, in turn, benchmarks against the prevailing market. It provides strong performance incentives which are commensurate with the prevailing pay packages for the private sector. In addition, its pro-family policies, commitment to train its staff for their professional and personal development, and rewarding good performers, ensure good organisational performance and development. Consequently, its overall performance has become undoubtedly one of the best in the world.

CORRUPTION

Corruption is endemic in most Asian utilities. However, it is not an issue at PUB, which emphasises staff integrity as a key organisational requirement. It has taken measures to prevent corruption by staff training on Code of Governance and Code of Conduct, effective internal control processes, regular audits and strong and immediate sanctions against those who may prove to be corrupt. Staff members are required to make annual declarations, which include Declaration of Assets and Investments and Declaration of Non-indebtness.

Complaints of corruption are promptly investigated and reported to Singapore´s Corrupt Practices Investigation Bureau. PUB is a part of the overall Singapore milieu where there are strong anti-corruption laws at the national level with appropriate sanctions that are regularly implemented. In addition, in recent decades, the Government has consistently shown its strong political will to curb all forms of corruption, and take firm actions against all and any form of corruption (see http://www.cpib.org.sg/aboutus.htm).

AUTONOMY

Absence of autonomy is one of the most fundamental problems which affect most utilities of the Asian developing countries. This creates a series of second order problems and constraints which further erode the efficiency of the utilities to perform their tasks efficiently.

A fundamental problem in most Asian cities has been that the process of setting tariffs is primarily controlled by the elected officials, who mostly resist increases because of perceived vested interests. Low levels of tariffs cannot have any impact in terms of managing demands. In fact, low levels of tariffs are not compatible with metering, especially as the cost of metering and processing the resulting information may be higher than the revenue metering can generate. The problem is further accentuated by low levels of tariff collection. Furthermore, politicians have preferred to keep domestic water prices artificially low, and subsidise it with much higher tariffs from commercial and industrial consumers. For example, according to a World Bank study, in India, domestic consumers used 90% of the water, but accounted for only 20% of the revenues. Domestic consumers were thus heavily cross-subsidised by commercial and industrial water users.

In contrast, PUB has a high level of autonomy and solid political and public support, which have allowed it to increase water tariffs in progressive steps between 1997 and 2000 (see Table 1). Water tariffs have not been raised since July 2000. This increase not only has reduced the average monthly household water demand but also has enabled PUB to generate funds not only for good and timely operation and maintenance of the existing system but also for investments for future activities.

Such an approach has enabled PUB to fund its new capex investments over the years from its own income and internal reserves. In 2005, for the first time, PUB tapped the commercial market for S$400 million bond issue. Under the Public Utilities Act, the responsible Minister for the Environment and Water Resources had to approve the borrowing. The budgeted capex for the year 2005 was nearly S$200 million.

Because of lack of autonomy, political interferences, and other associated reasons, internal cash generation of water utilities in developing countries to finance water supply and sanitation has steadily declined: from 34% in 1988, to 10% in 1991 and only 8% in 1998. Thus, the overall situation has been "lose-lose" for all the activities. The Singapore experience indicates that given autonomy and other appropriate enabling environmental conditions, the utilities can not only be financially viable but also perform their tasks efficiently.

Unlike many other similar Asian utilities, the PUB has extensively used private sector where it did not have special competence or competitive advantage in order to strive for the lowest cost alternative. Earlier, the use of private sector for desalination and wastewater reclamation has been noted. In addition, specific activities are often outsourced to private sector companies. According to the Asian Development Bank (November 2005), some S$2.7 billion of water-related activities were outsourced over the "last four years," and another S$900 million will be outsourced during "the next two years" to improve the water services.

OVERALL PERFORMANCE

No matter which performance indicators are used, PUB invariably comes to the top 5% of all the urban water utilities of the world in terms of its performance. Only a few of these indicators will be noted below:

- 100% of population have access to drinking water and sanitation.

- The entire water supply system, from water works to consumers, is 100% metered.
- Unaccounted for water as a percentage of total production was 5.18% in 2004.
- The number of accounts served per PUB employee was 376 in 2004
- Monthly bill collection efficiency: 99% in 2004.

Monthly bill collection in terms of days of sales outstanding was 35 days in 2004.

The above analysis indicates that PUB has initiated numerous innovative approaches to manage the total water cycle in Singapore. Many of these approaches can be adopted by developed and developing countries to improve their water management systems. If the MDGs that relate to water are to be reached, the example of Singapore needs to be seriously considered for adoption by developing countries concerned and the donor community, after appropriate modifications.

CONCLUDING REMARKS

Any objective analysis has to conclude that water supply and wastewater management practices in recent years in Singapore have been exemplary. Water demand management practices are unquestionably one of the best, irrespective of whether a public or private sector institution is managing the water services.

The country has successfully implemented what most water professionals have been preaching in recent years. By ensuring efficient use of its limited water resources through economic instruments, adopting latest technological development to produce "new" sources of water, enhancing storage capacities by proper catchment management, practicing water conservation measures, and ensuring concurrent consideration of social, economic and environmental factors, Singapore has reached a level of holistic water management that other urban centres will do well to emulate. ***AW***

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Block your dates for this Shanghai show

WSDWTF 2006 to be held in Shanghai, April 28-30, is a show which is well recognised by both domestic and international companies. Recently, all space in Floors 1& 2 of Intex Shanghai for the exhibition has been taken up.

In addition to exhibitors from China, many international exhibitors and their joint ventures in China have already signed up for the exhibition, including exhibitors from USA, UK, Germany, Australia, Japan, South Korea, Singapore, India and etc.

A total of 612 exhibitors will be staging their shows at WSDWTF 2006, bringing the latest state-of-the-art technologies and products to participate in the partnership forging and marketing activities in China. WSDWTF 2006, the seventh staging, would also offer the best opportunities for them to showcase their companies' latest environment equipment, technologies and applications to one of the fastest growing markets in the world.

To date, there are three overseas governmental agencies and associations among the groups of exhibitors setting up national pavilions in WSDWTF 2006. The organisers, Shanghai ZM Exhibition Service Co. Ltd., have been working well with the agencies and associations in the multi-facet relationships of the business. The organisers are honoured to get tremendous support from KWPIC, which has confirmed a space of 108 sq m to build its national pavilion. Besides, KIPA and Czech Trade also brought in eight and four exhibitors respectively to establish their pavilions.

There is tremendous support from many other foreign individual participants, such as Pentair Water (USA), ESRI (USA), Ebara (Japan), VERDER (Germany), Brunel University (UK), Eco-Safe (Italy), GlobalTech Environmental (Australia), SINWINCO (Malaysia), THERMAX (India), and etc.

Also, much help has been received from the General Consulate of the U.S. in Shanghai, the General Consulate of South Korea in Shanghai, Singapore Consulate in Shanghai and the General Consulate of U.K. in Shanghai, etc. The business departments of these consulates will organise the visiting delegates to tour the exhibition.

From the beginning of January 2006, the organisers have been working together with the Chinese Society for Environmental Sciences to invite specialised visitors to attend WSDWTF 2006. It is estimated that there will be more than 20,000 visitors at the exhibition.

During the exhibition, there will be a cocktail party, which would provide good opportunities for the exhibitors to communicate with professors and leaders of local governments and associations in this field. Undoubtedly, that would be an excellent platform for worldwide environmental and water industry players.

WSDWTF 2006 is the comprehensive exhibition on the Asian market for practical solutions in the key sectors of environmental protection and waste disposal, including water supply, sewage, recycling, air pollution, environmental technology and environmentally sound energy. The organisers have worked hard to come up with an exhibition which is set to deliver results. Based on the overall assessment, they are very confident that WSDWTF 2006 will be one of the best trade fairs in China, if not in the whole world. ***AW***

For more information about the show, please visit www.wsdwtf.com.